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DDS&T-167-83
1 MAR 1983

MEMORANDUM FOR: Public Affairs Division

FROM: R. E. Hineman
Deputy Director for Science and Technology

SUBJECT: Oral Presentation - Appearance Before
Non-Government Group - [redacted] STAT

1. Under the provisions of [redacted] STAT the attached oral presentation by [redacted], ORD/DDS&T to a STAT graduate course at George Washington University on 30 March 1983 is approved.

2. The content of this presentation has been reviewed by this office and is considered unclassified and consistent with established policies of the Agency and the U.S. Government.

3. Should you have any further questions regarding this matter, please contact this office directly.

[redacted] STAT

R. E. Hineman

Attachment:
As stated

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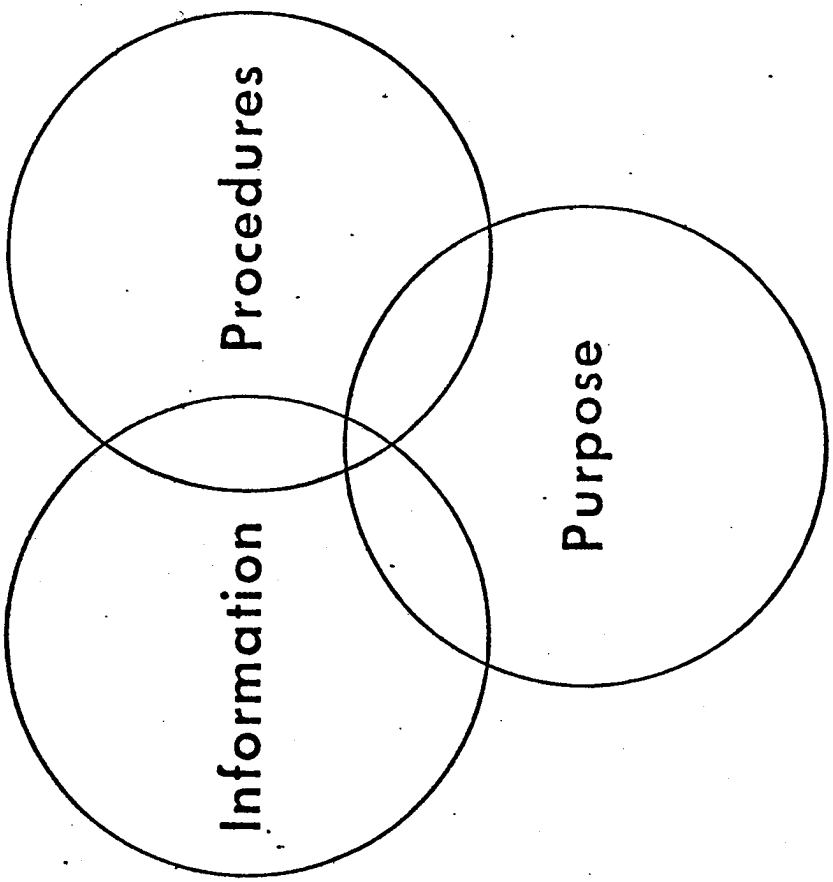
Knowledge Management



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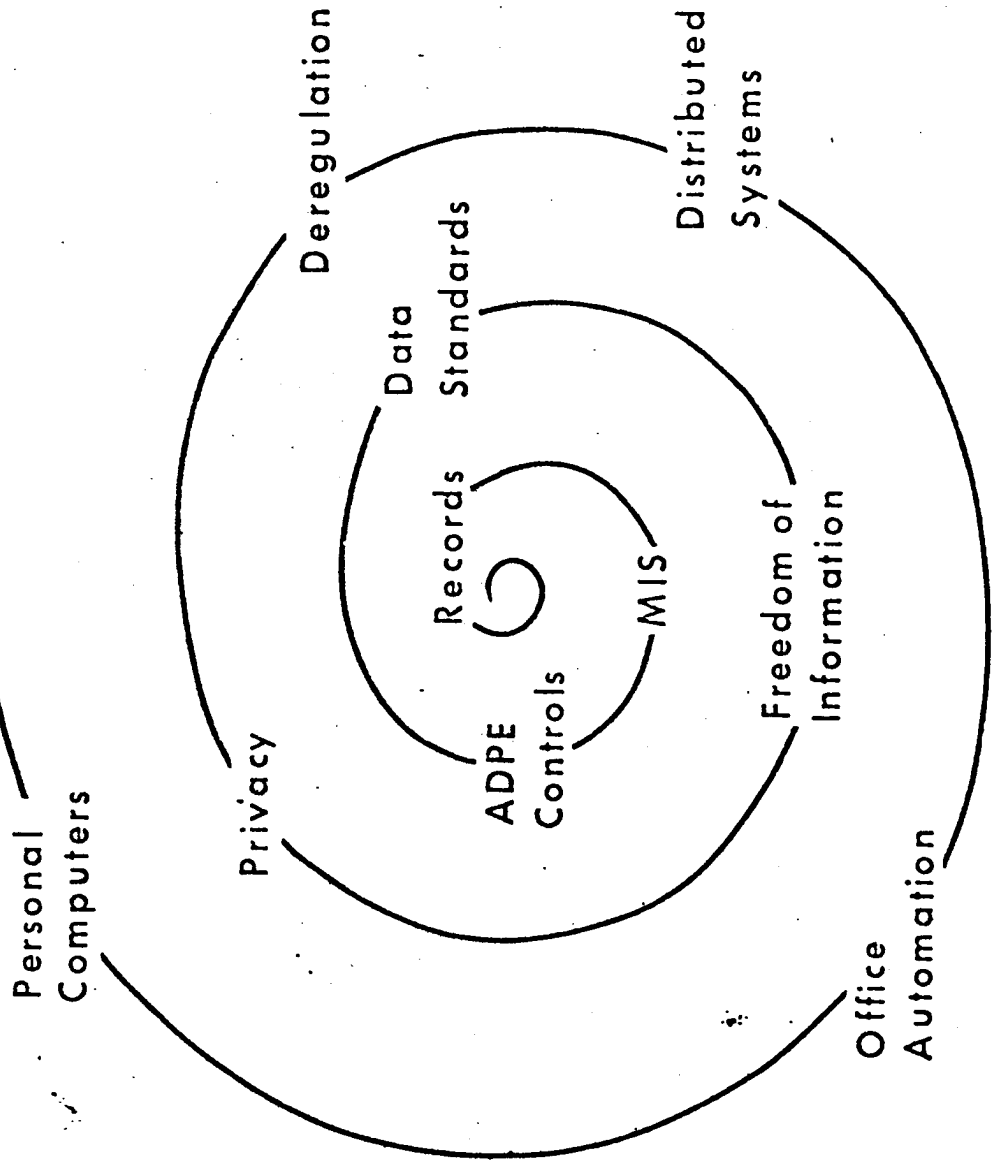
The Past



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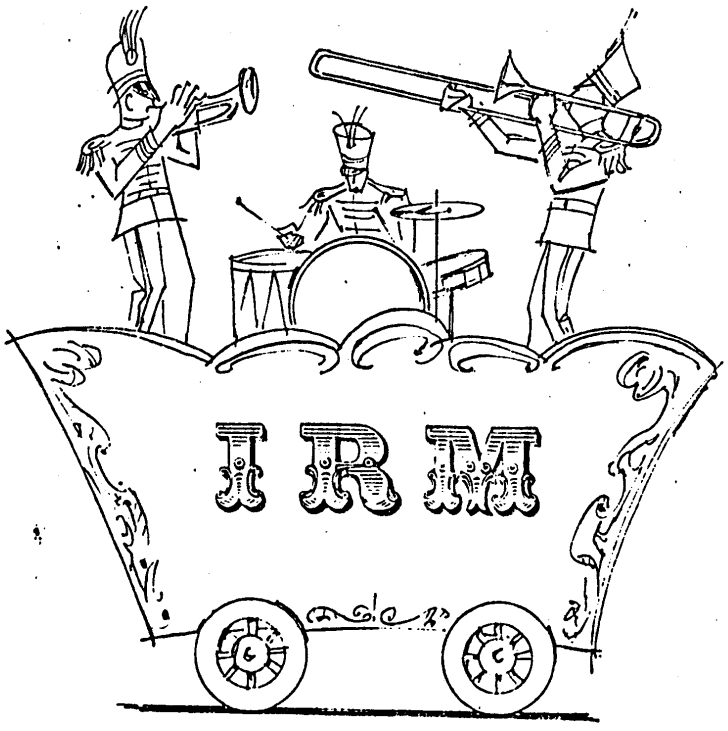
The Present



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Information Resources Management

INVOLVES

- THE MANAGEMENT (PLANNING, ORGANIZATION, DIRECTION, OPERATIONS, AND CONTROL)

OF

- THE RESOURCES (HUMAN, FISCAL, PHYSICAL, AND INFORMATIONAL)

CONCERNED WITH

- INTEGRATED SYSTEMS SUPPORT (DESIGN, DEVELOPMENT, ENHANCEMENT AND MAINTENANCE)

AND

- SERVICING (PROCESSING, TRANSFORMATION, DISTRIBUTION, STORAGE, RETRIEVAL, AND DISPOSAL)

OF

- THE ENTERPRISE'S INFORMATION (DATA, TEXT, VOICE, IMAGE)

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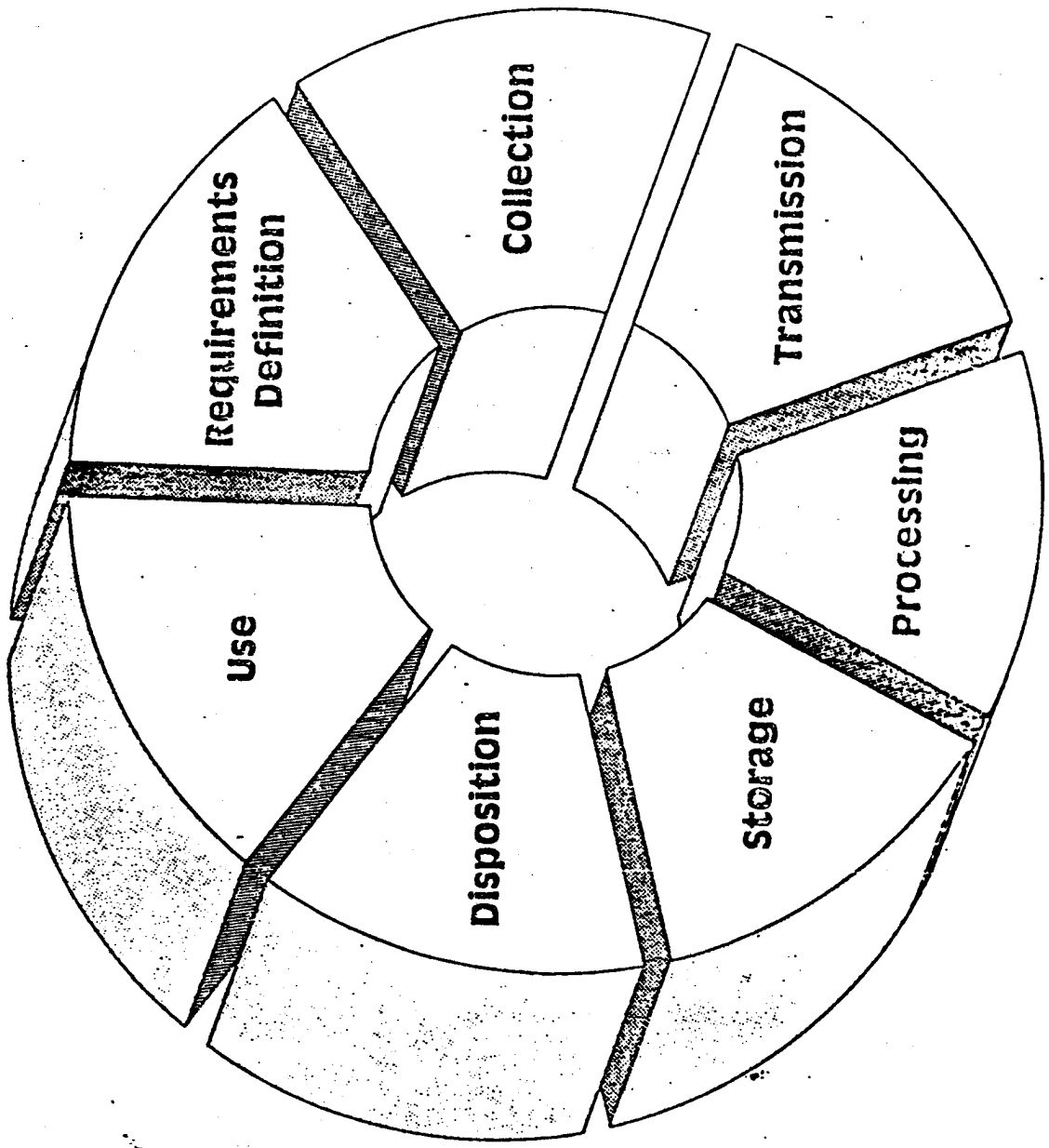
Information Life Cycle



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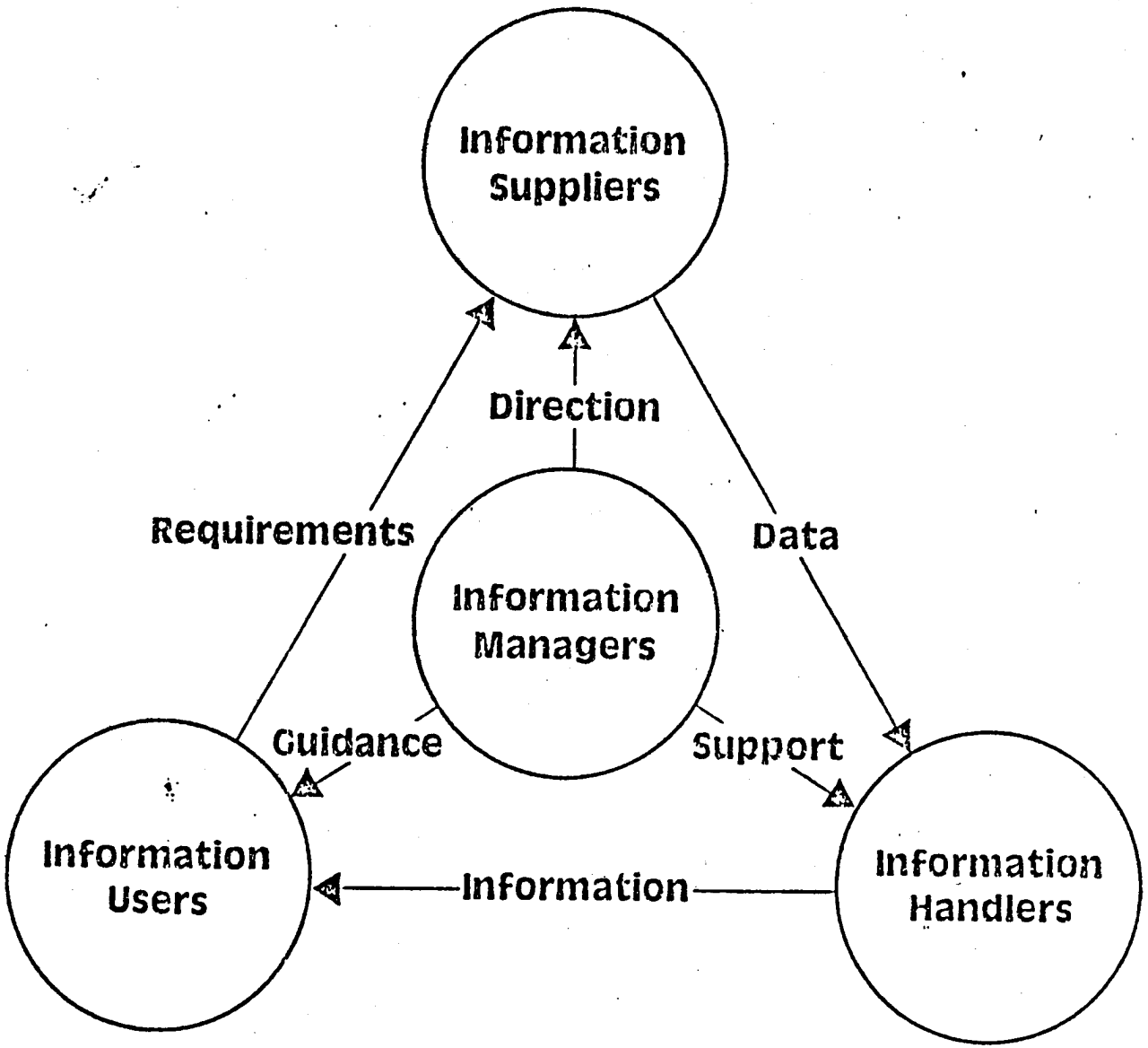
Information Life Cycle Management



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What the Future Holds for IRM

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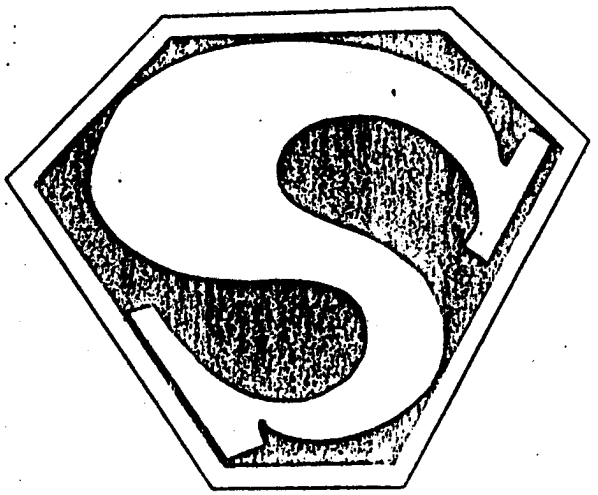
Technology

Faster

Friendlier



Cheaper

More Capacity

More Powerful

Smaller

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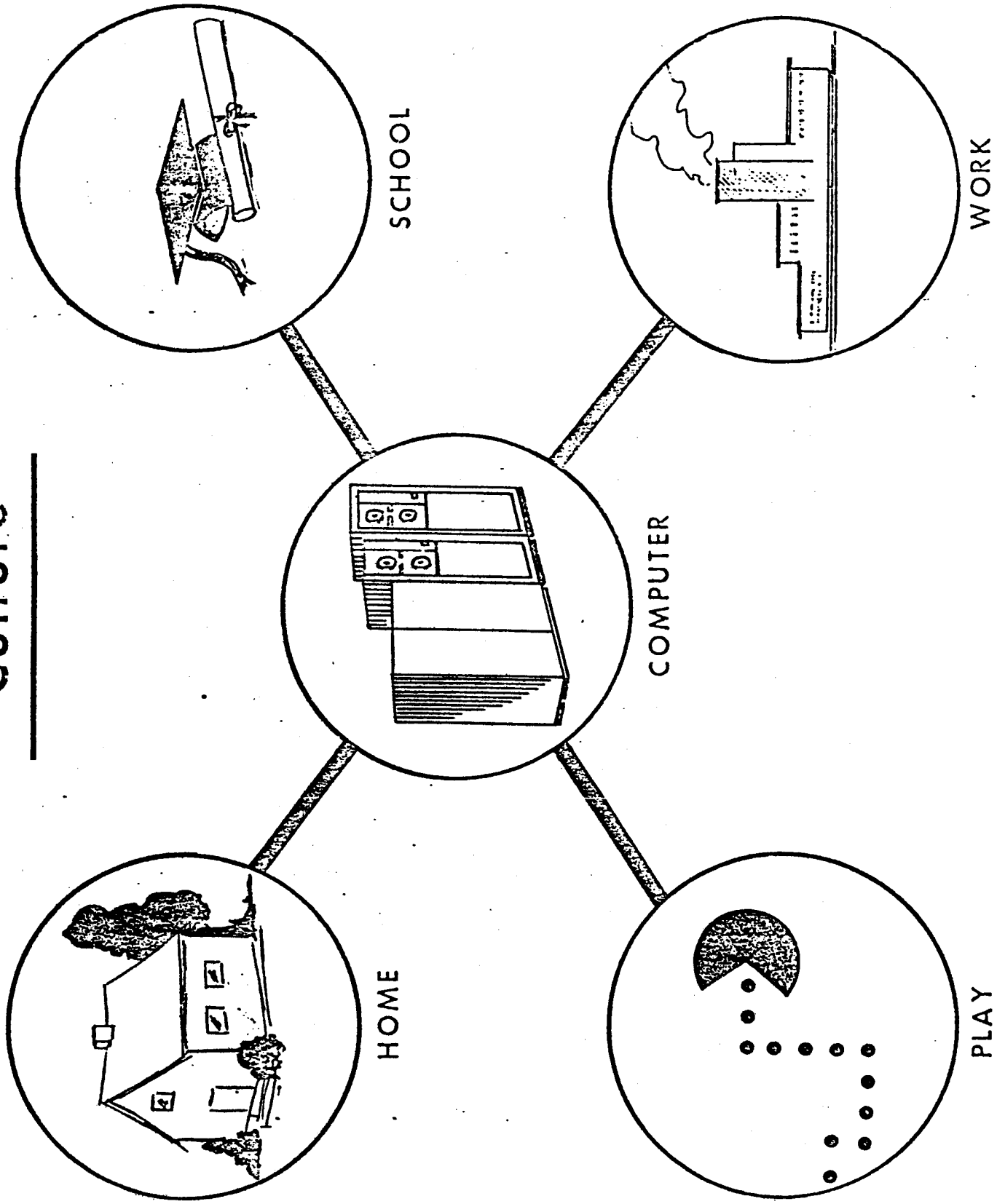
Culture



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Society Shift

	AGRARIAN	INDUSTRIAL	KNOWLED(
PRODUCT	Food	Goods	Information
WORK FORCE	Labor	Machines	Computers
WEALTH	Land	Money	Knowledge
SUCCESS	Yield/Acre	Productivity	Utility
TIME SCALE	Seasons	Days	Milliseconds
RESOURCES	Natural	Energy	Information
ISSUES	Husbandry	Conservation	Surfeit
INTERRELATIONS	Isolation	Transportation	Communicatio

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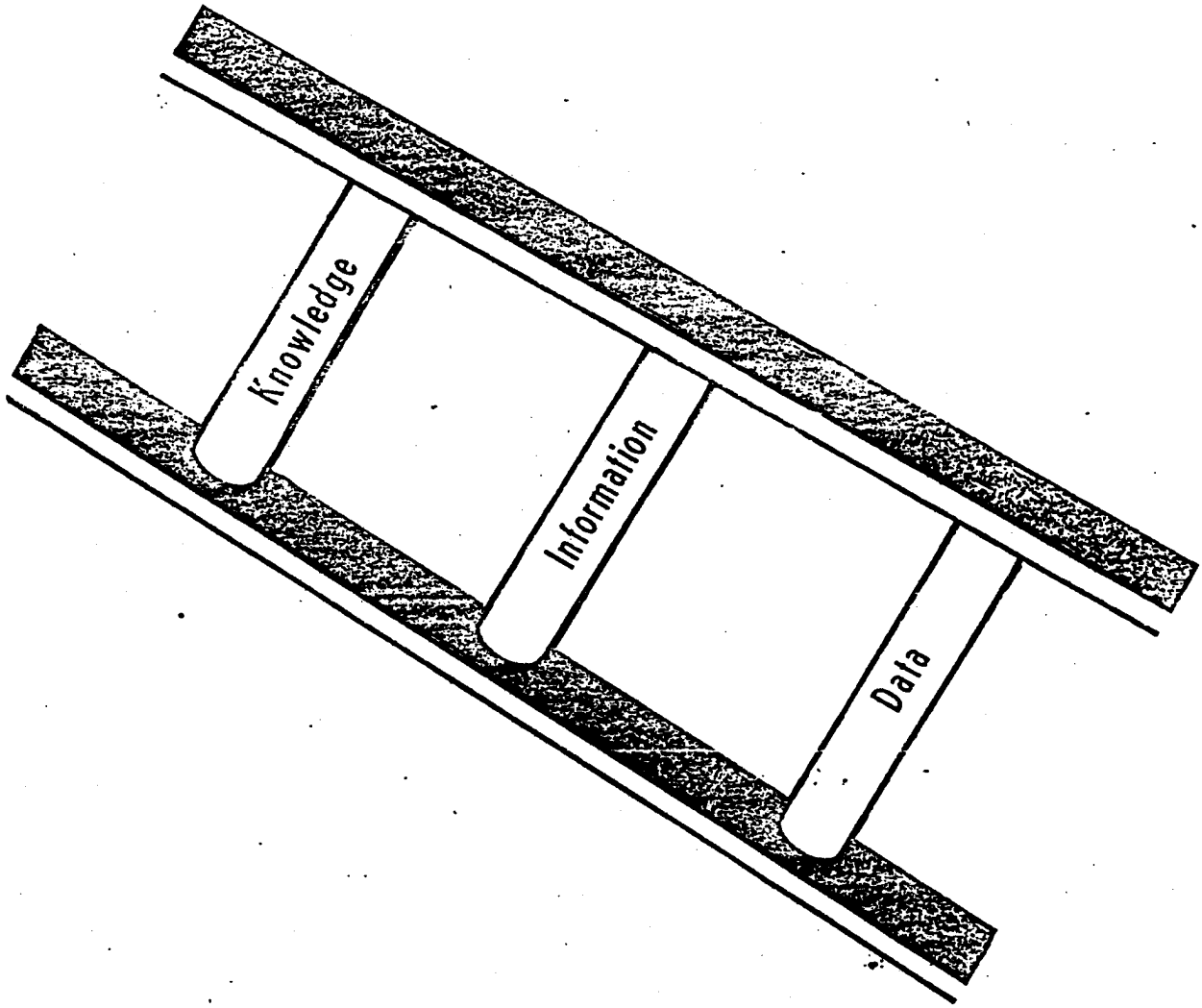
The Next Step



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Knowledge Management

- Knowledge Representation
- Metaknowledge Descriptions
- Symbolic Processing
- Knowledge Sources
- Knowledge Engineering
- High-Level Interfaces

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Common Knowledge-related Problems

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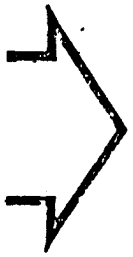
- Personnel Turnover
- High Data Volumes
- Uncertainty/Incompleteness
- Complex Analytical Processes
- Long System Development Cycle
- Rigid Systems
- Dynamic Environment



Potential Impacts

- Loss of Expertise
- Data Overload
- Information Underload
- Knowledge Obscurity
- Lower Productivity
- User Dissatisfaction
- Higher Maintenance Costs

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Knowledge Management Concepts

Manage Knowledge as a Resource
- Information
- Procedures
- Purpose

Integrate and Share Knowledge Resources
- From various sources
- In different representations
- Among components and domains

Capture Knowledge in Intelligent Systems
- Comprehensive data bases
- Improved analytical methodologies
- Applied artificial intelligence

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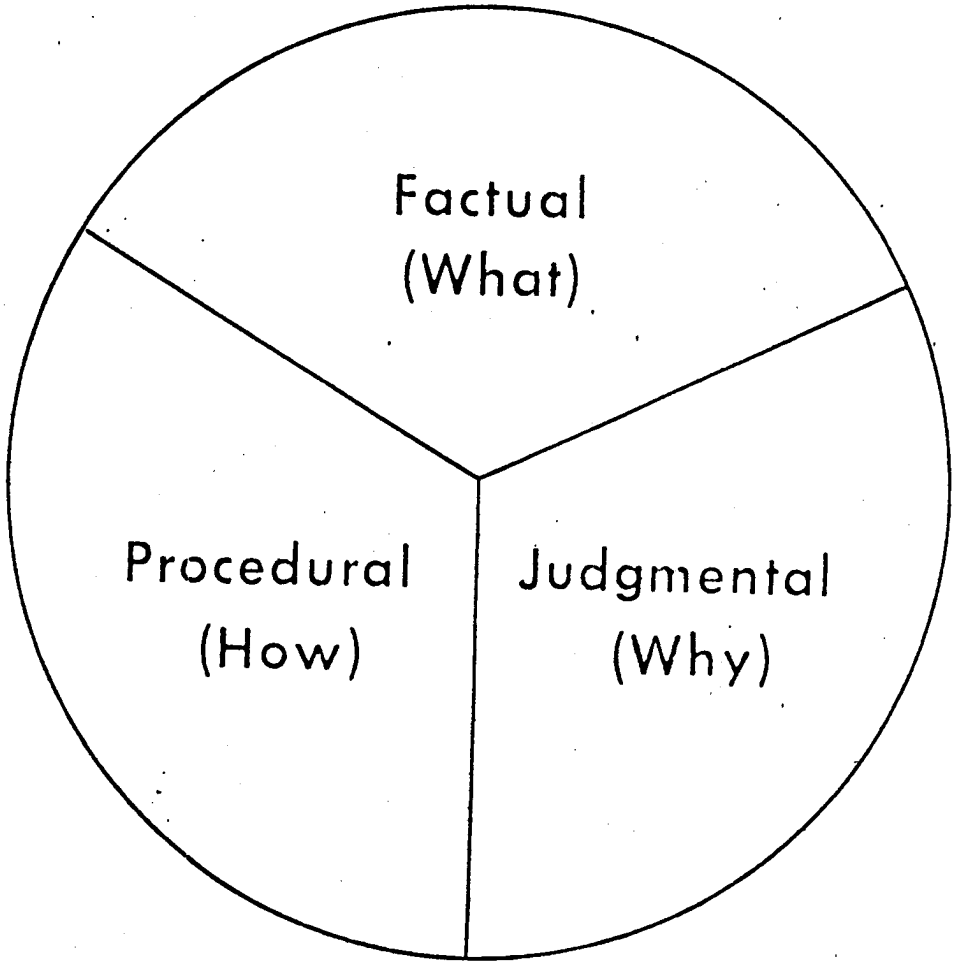
Knowledge Resource

Data
Relationships
Meanings



Programs
Procedures
Skills

Goals
Constraints
Wisdom

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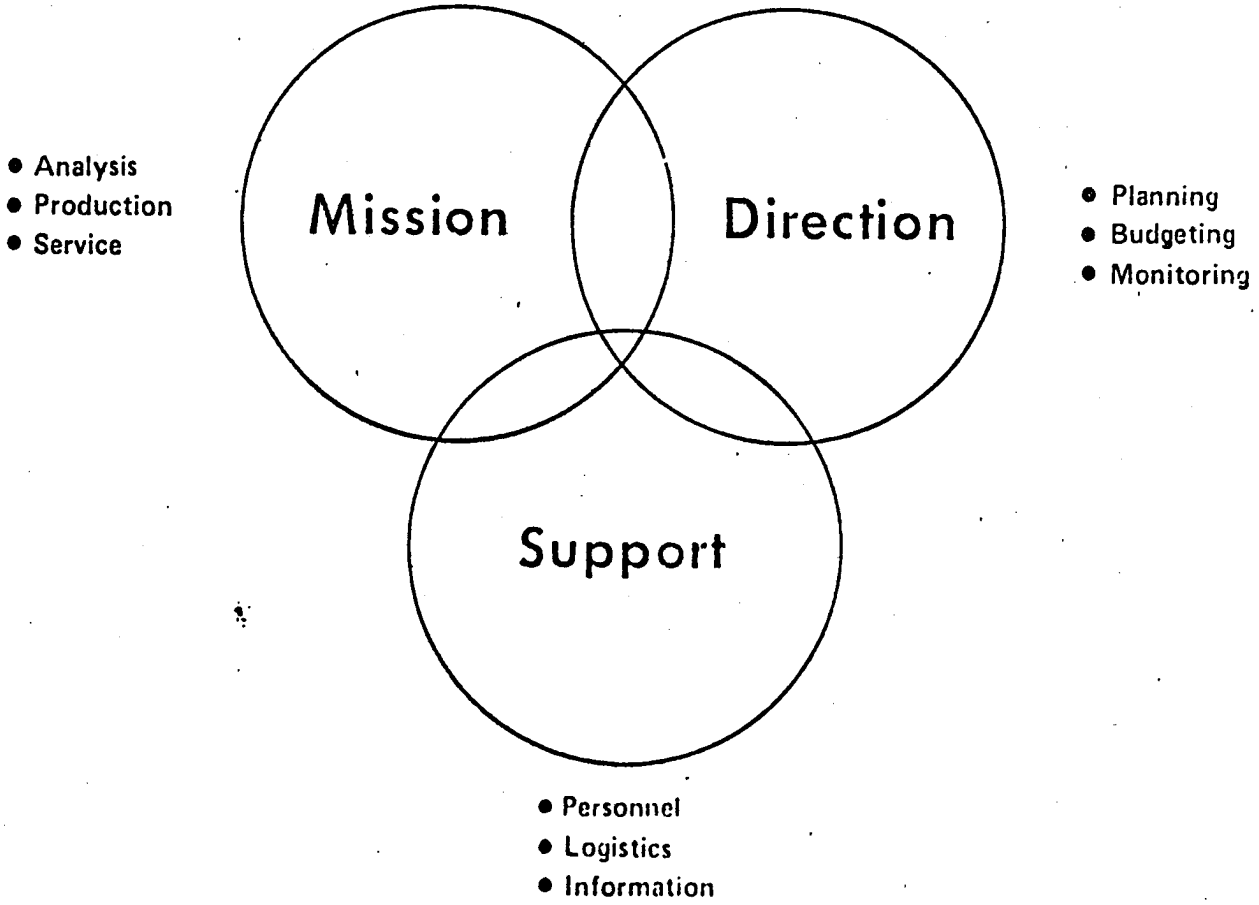
Broad Knowledge Domain Areas



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Artificial Intelligence

Artificial Intelligence (A/I) is that part of computer science concerned with designing systems that exhibit the characteristics we tend to associate with intelligence in human behavior, e.g.,

- Understanding language
- Learning from experience
- Logical reasoning
- Solving problems
- Explaining its behavior

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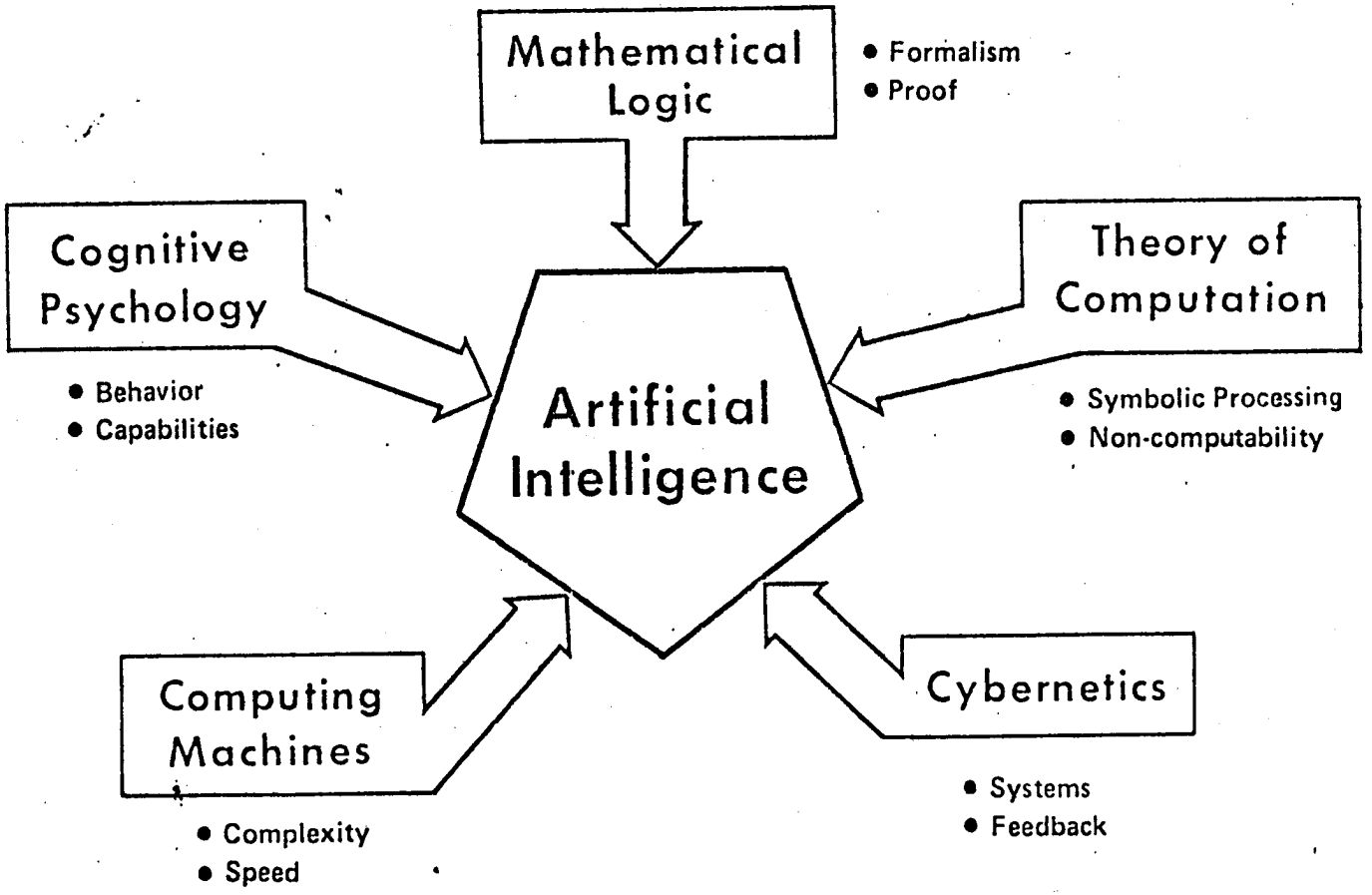
Influences on Artificial Intelligence



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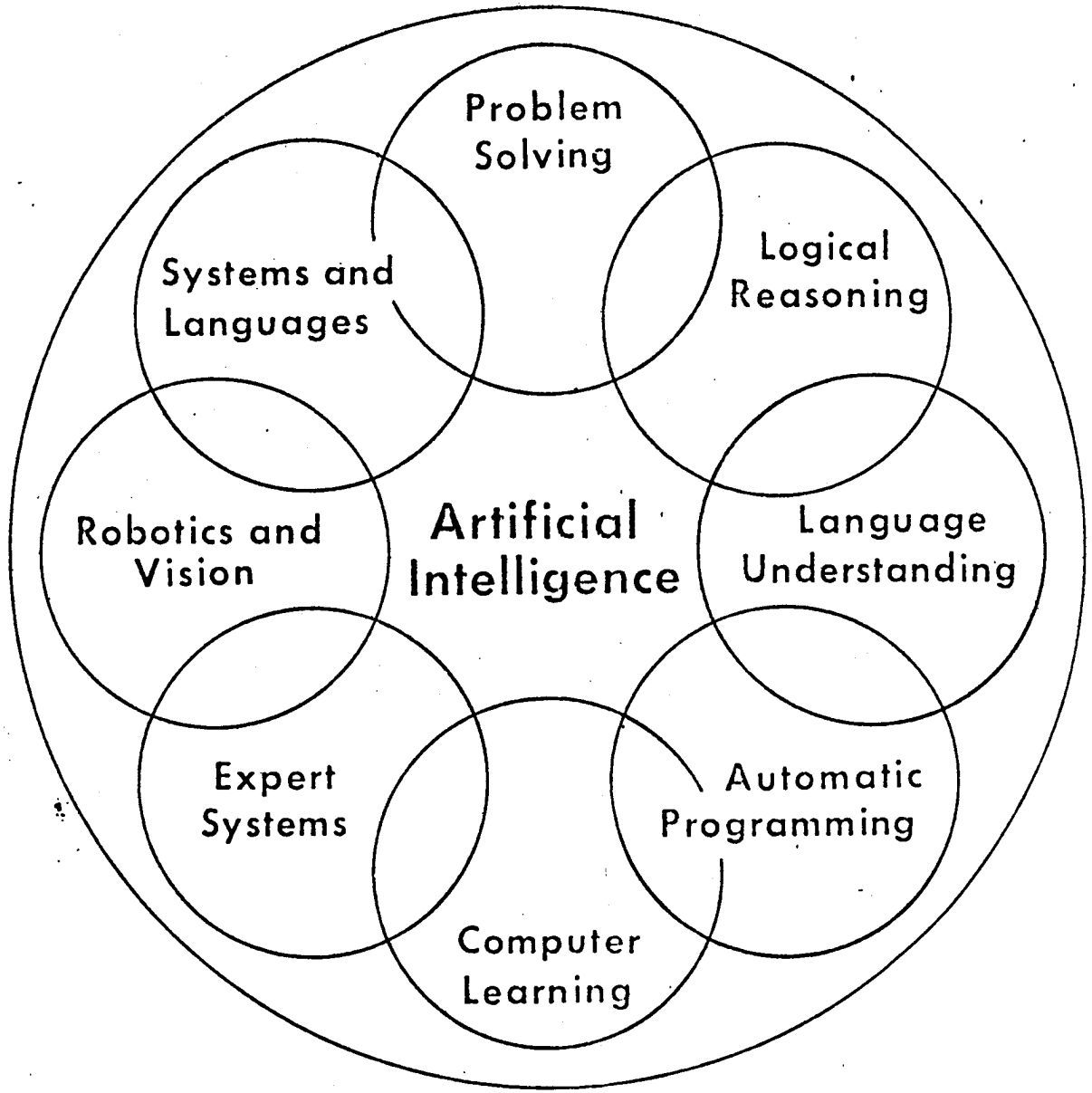
Disciplines of Artificial Intelligence



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Intelligent System

An Intelligent System is a computerized system which attempts to emulate the behavior of a human expert in solving difficult problems in a single, well-defined subject area. Intelligent Systems combine the power of the computer to consider many detailed alternatives with the wisdom of the expert to decide which alternatives are most likely to succeed.

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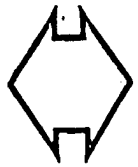
Benefits Sought from Intelligent Systems

GENERAL GOALS

- Institutionalize Expertise
- Reduce Retraining Costs
- Reduce User Confusion
- Improve Personal Productivity
- Solve Previously Untractable Problems
- Contain System Life Cycle Costs



SPECIFIC TECHNIQUES

- Expert Systems
- Self-Tutorial Systems
- High Level Interfaces
- Intelligent Assistants
- Heuristic Search
- Flexible Knowledge Representation

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Aspects of an Intelligent System

FUNCTIONS

- Correctly interpret partially formed queries
- Make intelligent inferences with incomplete data
- Eliminate extraneous material from responses
- Explain its behavior to system users
- Be readily modified to accommodate new knowledge

CHARACTERISTICS

- Separate knowledge base from program code
- Apply logical rules of inference to given facts
- Associate certainty factors with data and inferences
- Represent knowledge in easily understood form
- Manipulate symbols instead of crunching numbers

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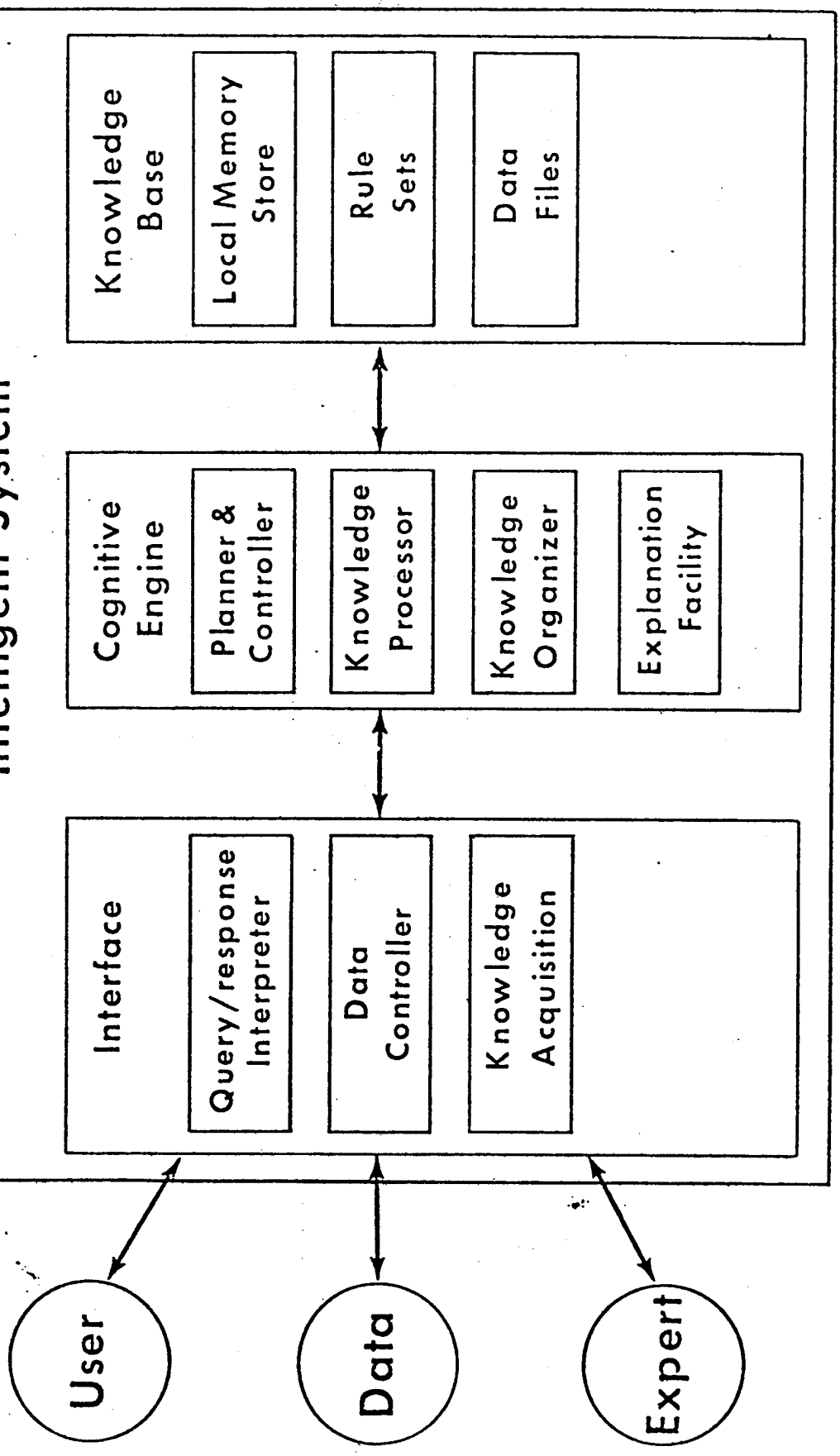
Intelligent System Conceptual Design



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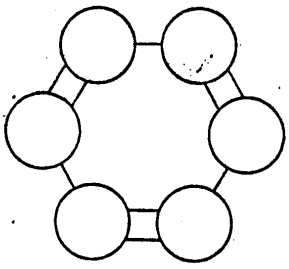
Selected Successful Examples



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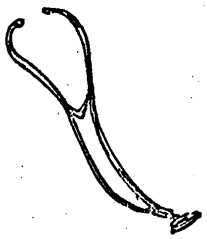
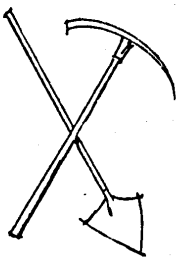


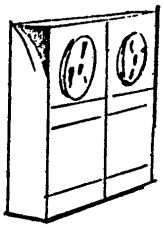
Mycin



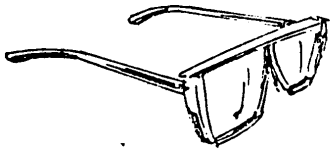
Prospector

$$\int x dx$$

Macsyma



R1



Acronym

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Goal-Oriented Reasoning

GOAL: Who is the Grandmother of Jennifer?

DATA: Michelle is the Mother of Jennifer
Craig is the Father of Jennifer
Josie is the Mother of Michelle
Mildred is the Mother of Craig

RULES: If: X is the Mother of Y and
Y is the Mother of Z
Then: X is the Grandmother of Z

If: X is the Mother of Y and
Y is the Father of Z
Then: X is the Grandmother of Z

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Example Rules

R1 (VAX CONFIGURATION)

If:
(1) The current context is assigning devices to Unibus modules, and
(2) There is an unassigned dual-port disk drive, and
(3) The type of controller it requires is known, and
(4) There are two such controllers, neither of which has any devices assigned to it, and
(5) The number of devices that these controllers can support is known

Then:
(1) Assign the disk drive to each of the controllers, and
(2) Note that the two controllers have been associated and that each supports one device.

MYCIN (MEDICAL DIAGNOSIS)

If:
(1) The site of the culture is blood,
(2) The identity of the organism is not known with certainty, and
(3) The stain of the organism is gramneg, and
(4) The morphology of the organism is rod, and
(5) The patient has been seriously burned

Then: There is weakly suggestive evidence (0.4) that the identity of the organism is pseudomonas.

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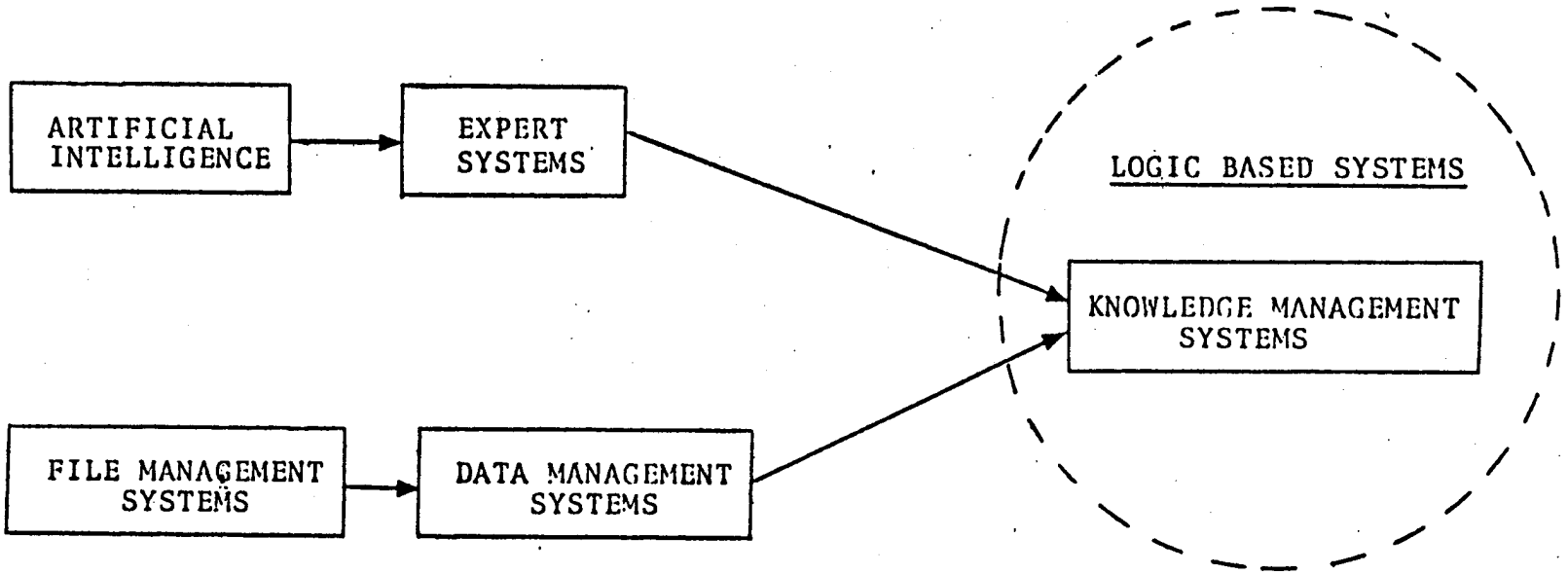
THE KNOWLEDGE MANAGER (KM-1)

GOAL: TO COMBINE KNOWLEDGE BASE AND INFORMATION MANAGEMENT TECHNOLOGY



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DEFINITIONS

- A LOGIC BASED SYSTEM DERIVES LOGICAL CONSEQUENCES FROM ITS KNOWLEDGE BASE

- A KNOWLEDGE BASE CONSISTS OF:

  - A FORMAL THEORY (SET OF LOGICAL RULES IN A RULE BASE) $[\text{north-of}(X,Y) \wedge \text{north-of}(Y,Z) \rightarrow \text{north-of}(X,Z)]$

  - A FORMAL MODEL (SET OF FACTS IN A RELATIONAL DATA BASE)

$$\left[\begin{array}{l}\text{north-of(Bonn,Brussels)}\\ \text{north-of(Amsterdam,Bonn)}\\ \text{north-of(Paris,Bern)}\\ \text{north-of(Brussels,Paris)}\end{array}\right]$$

- AN ANSWER TO A QUESTION (SOLUTION TO A PROBLEM) IS A LOGICAL CONSEQUENCE DERIVED FROM THE KNOWLEDGE BASE

Q: north-of(Bonn,Bern)
A: yes

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KNOWLEDGE MANAGEMENT COMPONENTS

- HARDWARE
- SOFTWARE
- APPLICATION SPECIFIC KNOWLEDGE

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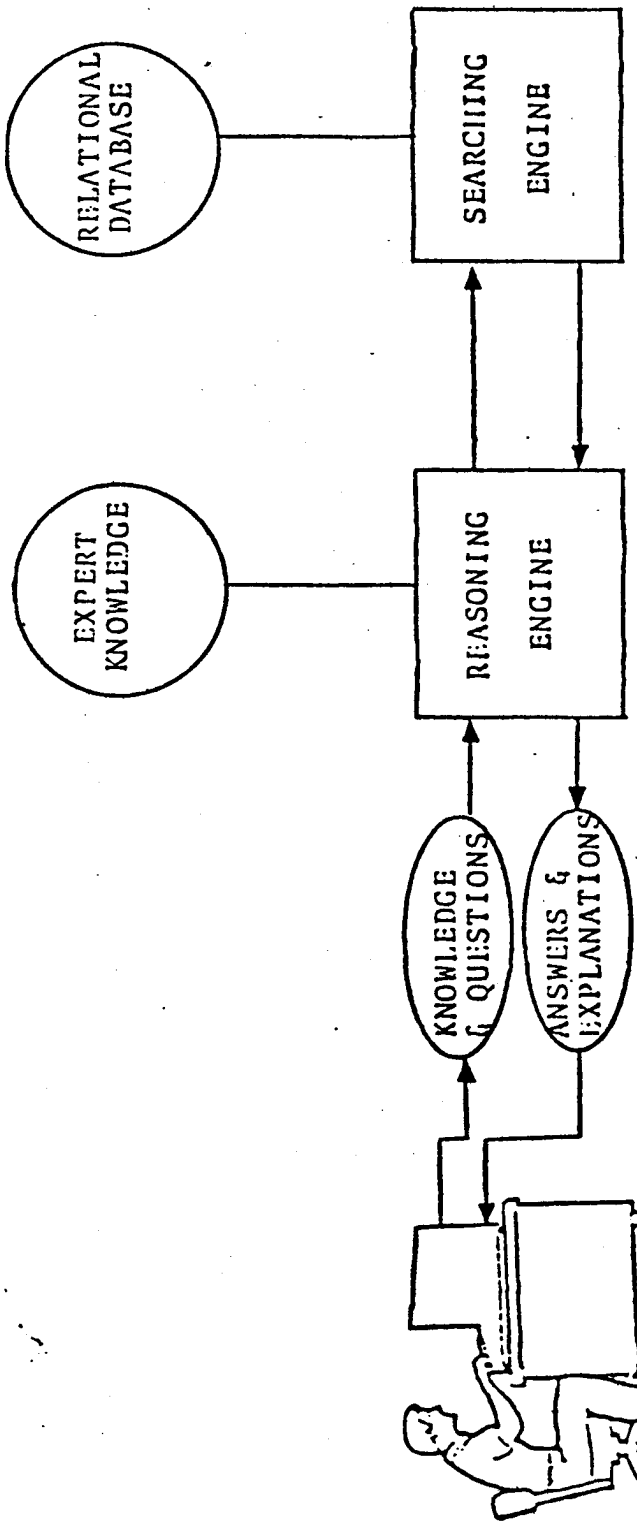
KNOWLEDGE MANAGER: FUTURE CONFIGURATION



System Development Corporation

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DADM

- REASONING WITH DATA - QUESTION-ANSWERING
  - FORWARD
  - BACKWARD
  - BI-DIRECTIONAL
- REASONING WITH DATABASE DESCRIPTIONS-INTEGRITY CHECKING
- DEDUCTION BY EXCEPTION
- DEDUCTION WITH PARTIAL INFORMATION
- DEDUCTION WITH PLAUSIBLE INFORMATION
- DEDUCTION OF CONDITIONAL ANSWERS
- DERIVATION OF PLANS TO CONTROL DEDUCTION/COMPUTATION/SEARCHING STEPS

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INTELLIGENT ASSISTANCE

FOR THE COMMANDER

WHERE IS THE MAIN THRUST COMING FROM?

FOR THE MANAGER

WHAT MIGHT ACCOUNT FOR THIS PLAN/ACTUAL DISCREPANCY?

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MANAGER'S ASSISTANT OBJECTIVE

DEMONSTRATE UTILITY OF KNOWLEDGE MANAGEMENT TECHNOLOGY WITH AN IN-HOUSE APPLICATION

- SAVE MANAGER TIME
- AID IN PLANNING, DATA ANALYSIS, DECISION MAKING
- PROVIDE ACCESS TO HISTORICAL DATA

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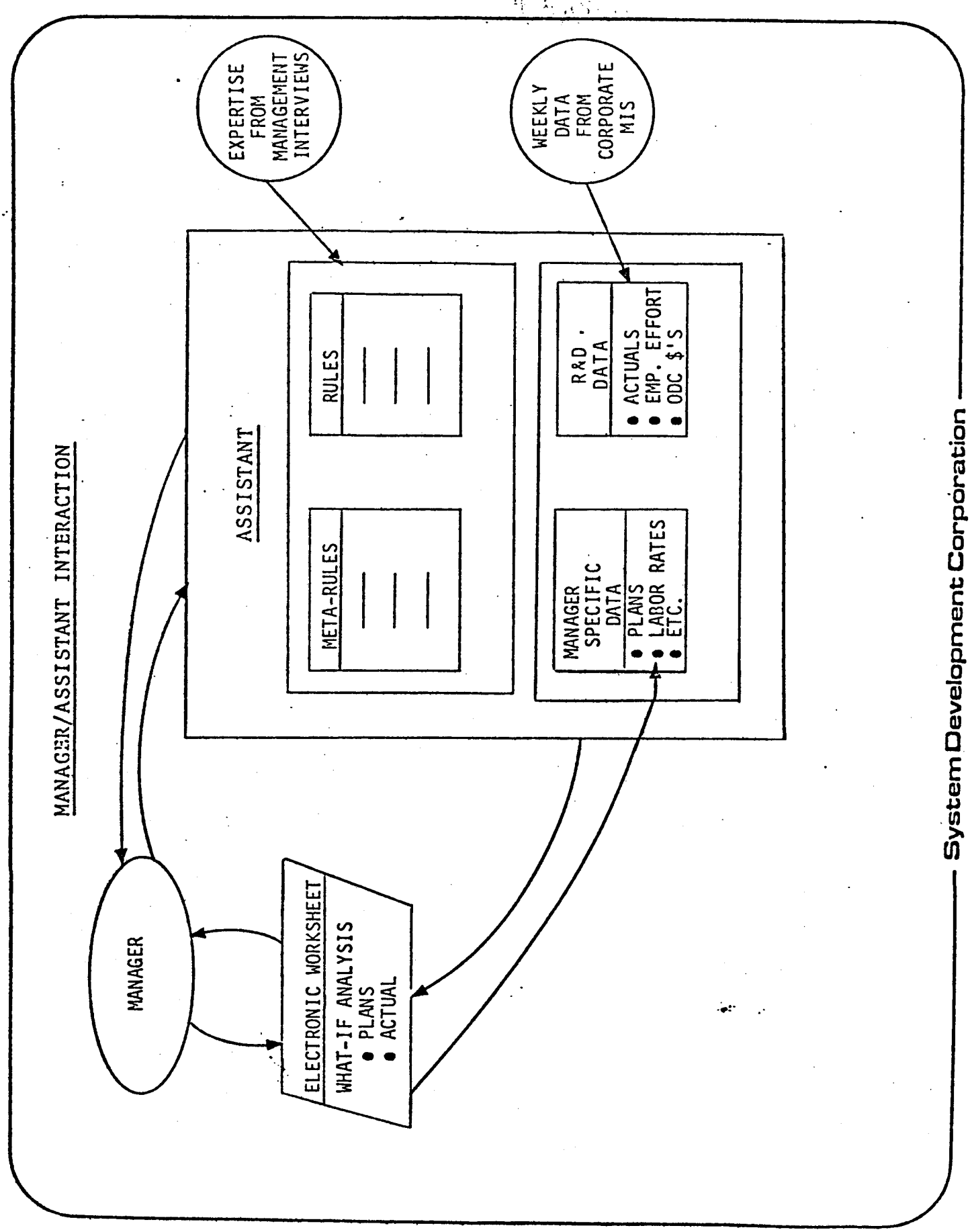

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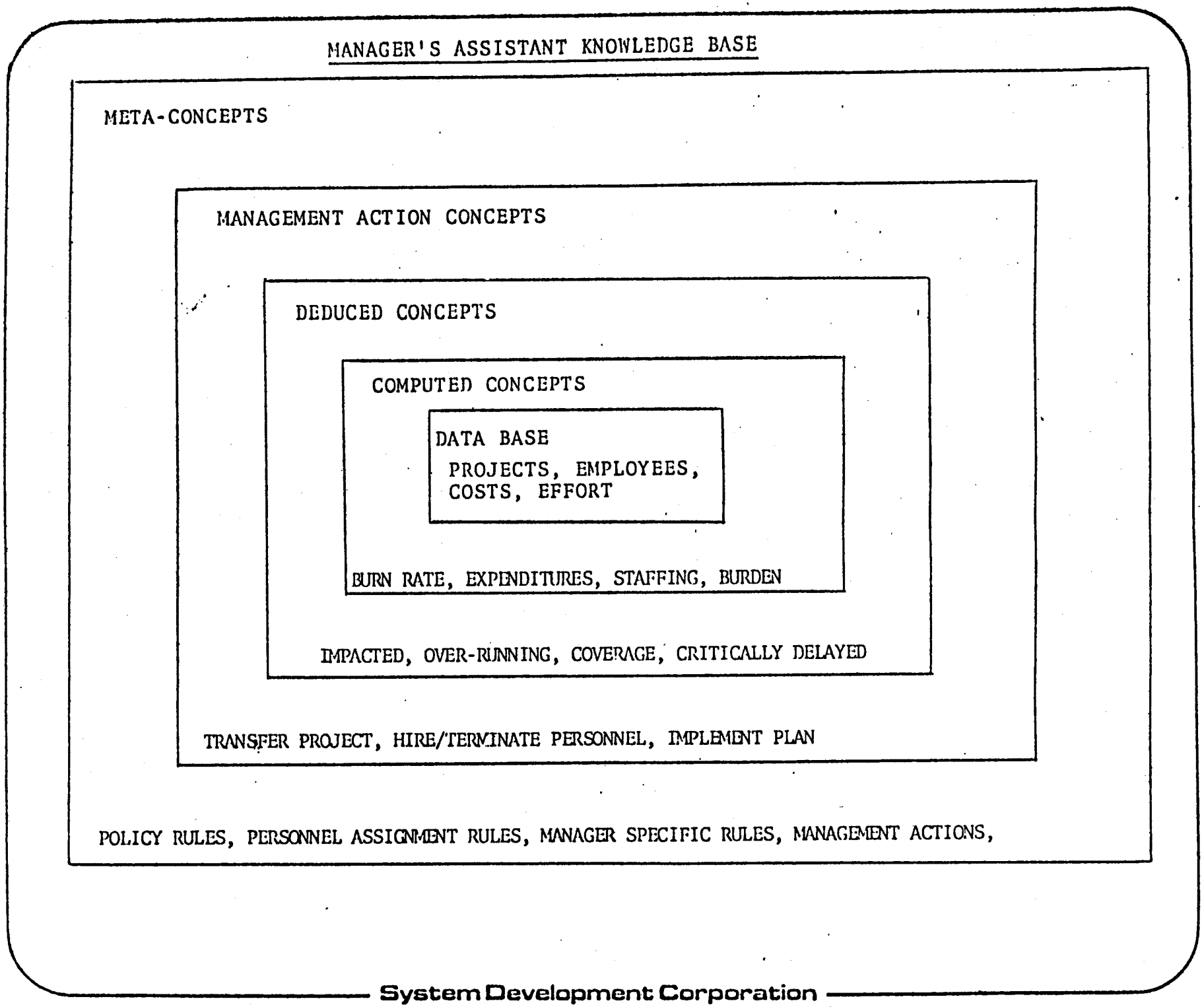

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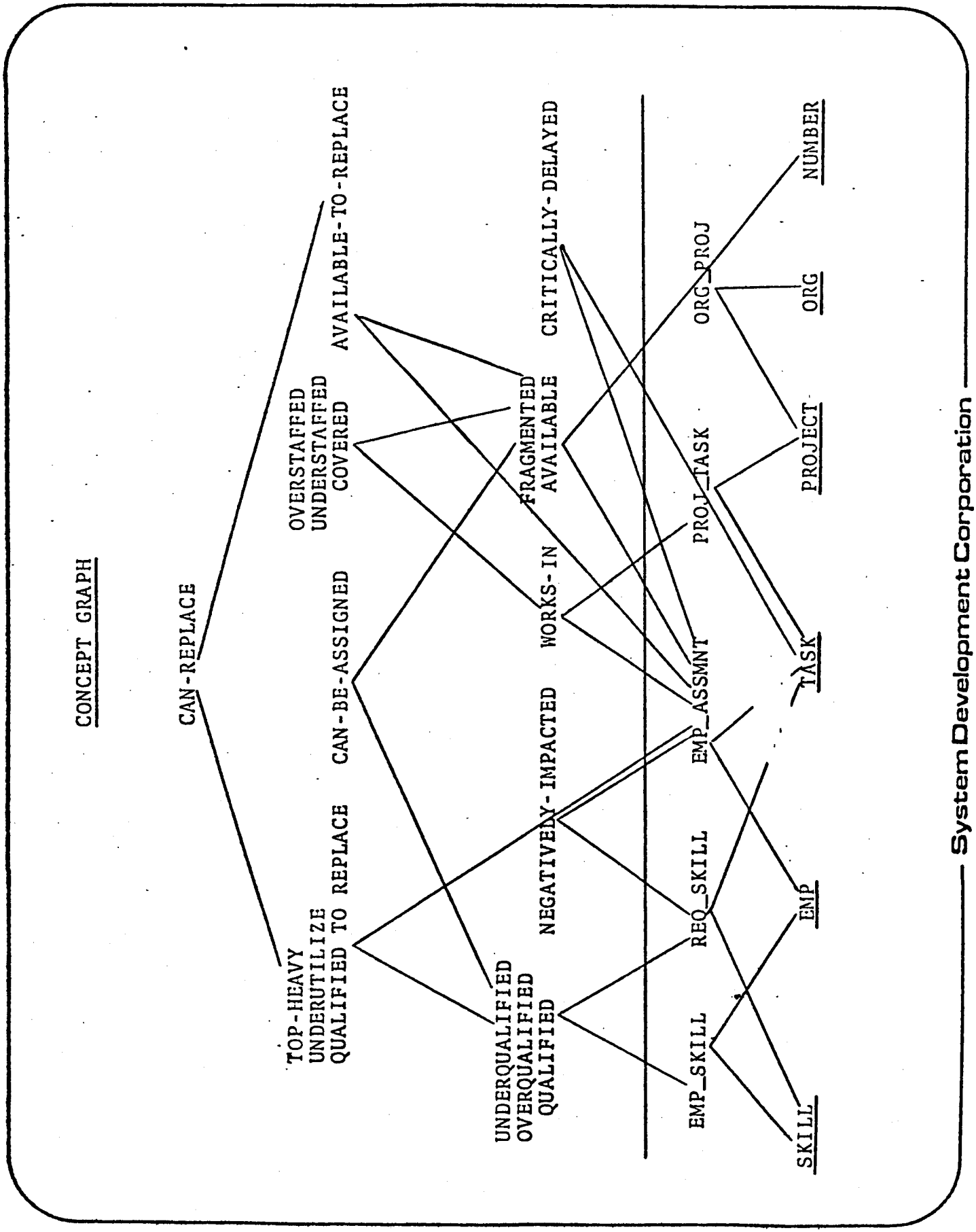

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QUERY

(FIND EMP-1 THAT CAN BE ASSIGNED TO IMPLEMENT TRON)

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RULES

IF EMPLOYEE-1 IS ASSIGNED TO PROJECT-1 FOR PERCENTAGE-1

AND EMPLOYEE-1 CAN BE REMOVED FROM PROJECT-1

THEN EMPLOYEE-1 IS AVAILABLE FOR PERCENTAGE-1

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IDM-500 DATABASE

```
1) range of rs is req_skill
2) retrieve (rs.all) go
```

task_i	skill_name	skill_	nhours
t001	Logic_and_Databases	3	30
t003	Database_Design	2	20
t002	LISP_Programming	3	20

```
1) range of ti is task_info
2) retrieve (ti.all) go
```

task_i	task_name	strt_dat	stop_dat	critic
t001	Implement_Tron	01-02-81	01-04-81	3
t002	Connect_Dolphin_to_IDM	01-04-81	01-05-81	3
t003	Design_Database	15-04-82	15-08-82	2

```
1) range of ea is emp_assmnt
2) retrieve (ea.all) go
```

emp_id	task_i	nhours
10190	t001	20
10190	t003	10
20575	t002	40

```
1) range of ei is emp_info
2) retrieve (ei.all) go
```

emp_id	enam	ecat	org_id	start_da
10190	Smith_John	c09	sdc401	19-09-64
20575	Van_Buer_Darrel	c06	sdc401	06-04-79

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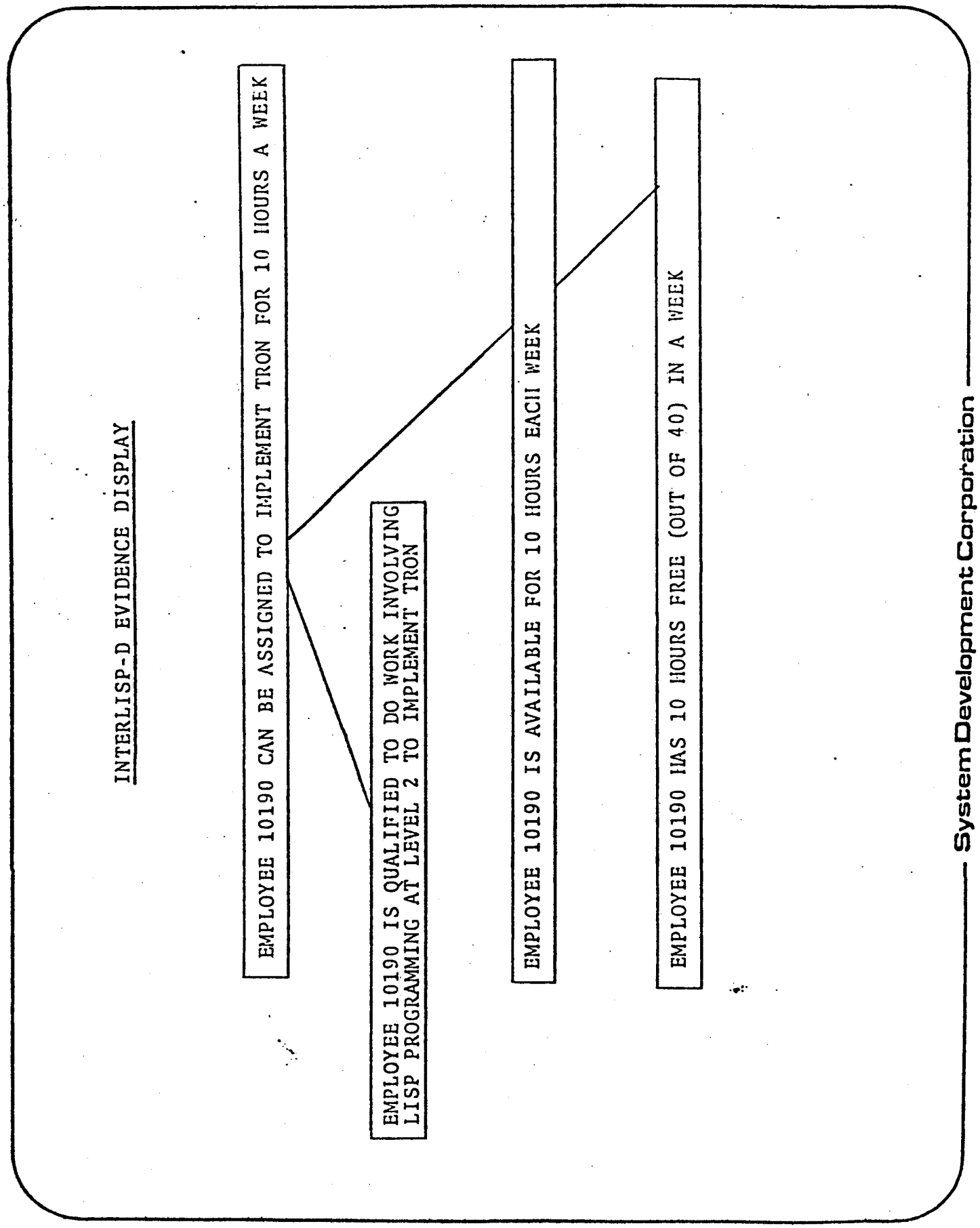
INTERLISP-D EVIDENCE DISPLAY
EMPLOYEE 10190 CAN BE ASSIGNED TO IMPLEMENT TRON FOR 10 HOURS A WEEK
EMPLOYEE 10190 IS QUALIFIED TO DO WORK INVOLVING LISP PROGRAMMING AT LEVEL 2 TO IMPLEMENT TRON
EMPLOYEE 10190 IS AVAILABLE FOR 10 HOURS EACH WEEK
EMPLOYEE 10190 HAS 10 HOURS FREE (OUT OF 40) IN A WEEK
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INTERLISP EVIDENCE CHAIN PRINTOUT

```
**3
FACT:  The employee id for employee SMITH_JOHN is 10190, the
       category is C09, the organization id is SOC401, and the
       date of hire is 19-09-64 (dd-mm-yy).
CONCLUDE:  Employee 10190 has 10 hours free (out of 40) in a week.

**2
COMPUTED:  10 is greater than 0.
CONCLUDE:  Employee 10190 is available for 10 hours each week.

**1
COMPUTED:  3 is greater than or equal to 2.
FACT:  Task T001 requires skills in LISP_PROGRAMMING at level 2
       (scale: 0 to 3) for 30 hours a week.
FACT:  Employee 10190 has skills in LISP_PROGRAMMING at level 3
       (scale: 0 to 3).
CONCLUDE:  Employee 10190 is qualified to do work involving LISP_PROGRAMMING
           at level 2 to IMPLEMENT_TRON.

**0
FACT:  Task T001 requires skills in LISP_PROGRAMMING at level 2
       (scale: 0 to 3) for 30 hours a week.
CONCLUDE:  Employee 10190 can be assigned to IMPLEMENT_TRON for 10 hours
           a week.
```


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DERIVED DATA BASE ACCESS STRATEGY

```
range of A0022 is EMP_SKILL
range of A0023 is REQ_SKILL
range of A0024 is EMP_INFO
range of A0025 is REQ_SKILL
retrieve(A0022.1,A0022.2,A0022.3,A0023.3,A0023.4,A0024.2,A0024.3,A0024.4,A0024.5)
  where(A0023.1="T001")
  and(A0023.2=A0022.2)
  and(A0024.1=A0022.1)
  and(A0025.1="T001")
  and(A0025.2=A0022.2)
  and(A0025.3=A0023.3)
```


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TRANSITIONING FROM DATA MANAGEMENT TO KNOWLEDGE MANAGEMENT

- LOGIC PROVIDES:
  - A PRECISE PROOF (REASONING WITH RULES) THEORY
  - A PRECISE MODEL (REPRESENTATION OF DATA) THEORY
- OUR LOGIC BASED SYSTEM:
  - PRODUCES PROOFS OF THE CORRECTNESS OF THE ANSWERS IT GENERATES
  - SUPPORTS A NATURAL AND ADVANTAGEOUS SEPARATION OF RULE BASE FROM DATA BASE AND REASONING ENGINE FROM SEARCHING ENGINE

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DADM PROCESSES

- DEDUCTIVE PATHFINDING
- GENERATION OF INFERENCE PLANS
- VERIFICATION OF INFERENCE PLANS
- GENERATION AND EXECUTION OF SEARCH/COMPUTE PLANS
- DATA BASE SEARCH AND ANSWER EXTRACTION
- EVIDENCE DISPLAY

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A CLASSICAL DEDUCTION

OR

A NOVEL EXPERIENCE

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SHERLOCK HOLMES

"SO, WATSON,...YOU DO NOT PROPOSE TO INVEST IN SOUTH AFRICAN SECURITIES?"

"HOW ON EARTH DO YOU KNOW THAT?" I ASKED.

"...IT WAS NOT REALLY DIFFICULT, BY AN INSPECTION OF THE GROOVE BETWEEN YOUR LEFT FOREFINGER AND THUMB, TO FEEL SURE THAT YOU DID NOT PROPOSE TO INVEST YOUR SMALL CAPITAL IN THE GOLDFIELDS."

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"HERE ARE THE MISSING LINKS OF THE VERY SIMPLE CHAIN:

1. YOU HAD CHALK BETWEEN YOUR LEFT FINGER AND THUMB WHEN YOU RETURNED FROM THE CLUB LAST NIGHT.

2. YOU PUT CHALK THERE WHEN YOU PLAY BILLIARDS TO STEADY THE CUE.

3. YOU NEVER PLAY BILLIARDS EXCEPT WITH THURSTON.

4. YOU TOLD ME FOUR WEEKS AGO THAT THURSTON HAD AN OPTION ON SOME SOUTH AFRICAN PROPERTY WHICH WOULD EXPIRE IN A MONTH, AND WHICH HE DESIRED YOU TO SHARE WITH HIM.

5. YOUR CHEQUE-BOOK IS LOCKED IN MY DRAWER, AND YOU HAVE NOT ASKED FOR THE KEY.

6. YOU DO NOT PROPOSE TO INVEST YOUR MONEY IN THIS MANNER."

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"HOW ABSURDLY SIMPLE!" I CRIED.

"QUITE SO!" SAID HE.

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THE SECRET OF HOLMES SUCCESS

- HE HAD ACCESS TO A LARGE DATA BASE OF FACTS
- HE WAS ABLE TO DEDUCE PLAUSIBLE IMPLICIT INFORMATION FROM EXPLICIT DATA

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MECHANIZING DEDUCTION TO EXTEND DATA MANAGEMENT

QUERY: GIVEN HOLMES OBSERVED CHALK IN GROOVE

CAN HOLMES CONCLUDE WATSON DID NOT BUY SECURITIES?

INFERENCE PLAN:

PREMISE: IF HOLMES KNEW WATSON PLAYED BILLIARDS WITH THURSTON
AND HOLMES KNEW THURSTON WANTED WATSON TO SHARE SECURITIES
AND HOLMES KNEW WATSON DID NOT HAVE CHEQUE BOOK
THEN HOLMES KNEW WATSON DID NOT BUY SECURITIES.

PREMISE: IF HOLMES OBSERVED CHALK IN GROOVE
THEN HOLMES KNEW WATSON PLAYED BILLIARDS

PREMISE: IF HOLMES KNEW WATSON PLAYED BILLIARDS
THEN HOLMES KNEW WATSON PLAYED BILLIARDS WITH THURSTON

FIND: HOLMES KNEW THURSTON WANTED WATSON TO SHARE SECURITIES.

FIND: HOLMES KNEW WATSON DID NOT HAVE CHEQUE BOOK.

ANSWER: YES

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A CLASSICAL DEDUCTION

- INFERENCE PLANS ARE SKELETAL PROOFS
- SEARCH/COMPUTE PLANS ARE DERIVED FROM INFERENCE PLANS
- THE EVALUATION OF SEARCH/COMPUTE PLANS YIELDS DATA THAT--WHEN INSERTED INTO AN INFERENCE PLAN--CONVERTS IT INTO A CORRECTNESS PROOF OR EVIDENCE CHAIN
- DADM MAY BE VIEWED AS A SYSTEM THAT:
  - DECOMPOSES A USER'S QUERY INTO A SERIES OF SUBPROBLEMS
  - MARKS SUBPROBLEMS FOR DEDUCE, SEARCH, COMPUTE, OR USER SUPPORT
  - SOLVES THE SUBPROBLEMS IN AN APPROPRIATE, EFFICIENT ORDER

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CONCLUSIONS

- CURRENT HARDWARE AND SOFTWARE CAN BE COMBINED TO TRANSITION FROM DATA MANAGEMENT TO KNOWLEDGE MANAGEMENT
- PERFORMANCE IS GREATLY ENHANCED WITH STATE-OF-THE-ART HARDWARE
- MUCH REMAINS TO BE DONE IN IMPROVING/EXTENDING THE SOFTWARE
- AUGMENTING A DMS WITH A LOGIC-BASED REASONING ENGINE PROVIDES A BASIS FOR REALIZING LARGE SCALE:

  QUESTION ANSWERING
  DATA ANALYSIS
  DECISION SUPPORT
  EXPERT SYSTEM
  } APPLICATIONS

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Some Potential Application Areas

- Expert systems supporting mission domains
- Large-scale simulation and modeling aids
- Intelligent assistance for routine processing
- Focusing searches through massive data files
- Diagnosis of system failures
- Automated aids for image understanding
- Improved techniques for understanding natural language
- Enhanced interfaces to data base management systems
- Computer-aided instruction
- Computer-aided design of microcircuitry

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Some Issues in Knowledge Engineering

- Application selection
- Knowledge representation
- Problem-solving approach
- Search feasibility and efficiency
- Multiple knowledge sources
- Knowledge engineering tools
- Scarcity of knowledge engineers

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Application Selection Criteria

- No known closed-form solution
- Existence of a domain expert
- Expert availability
- Expert's mental model of problem solution
- Well-bounded domain
- Generally agreed upon underlying theory
- User acceptance of plausible results
- Addresses an important problem

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Knowledge Representation

Logic

$(\forall x)$ Bird (x) $\supset$ has wings (x)

Production System

If X is a bird
Then X has wings

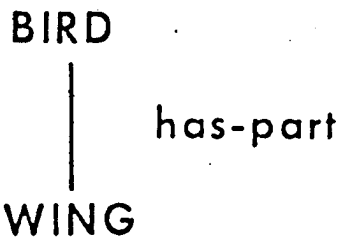
Procedural

```
   DO 10 X=1, 1, N
   IF IBIRD (X) .EQ. 1 IWINGS (X)=1
10 CONTINUE
```

Frames

self:	Animal
species:	
owner:	Person
part:	Wing
	Tail
	Head

Semantic Net



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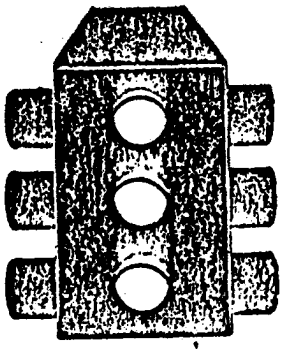
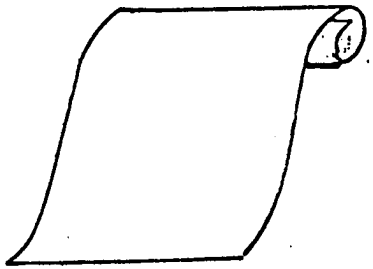
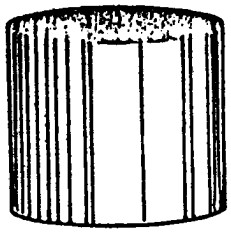
Problem Solving Approach



Control Strategy



Operator Set



State Space
Data Base

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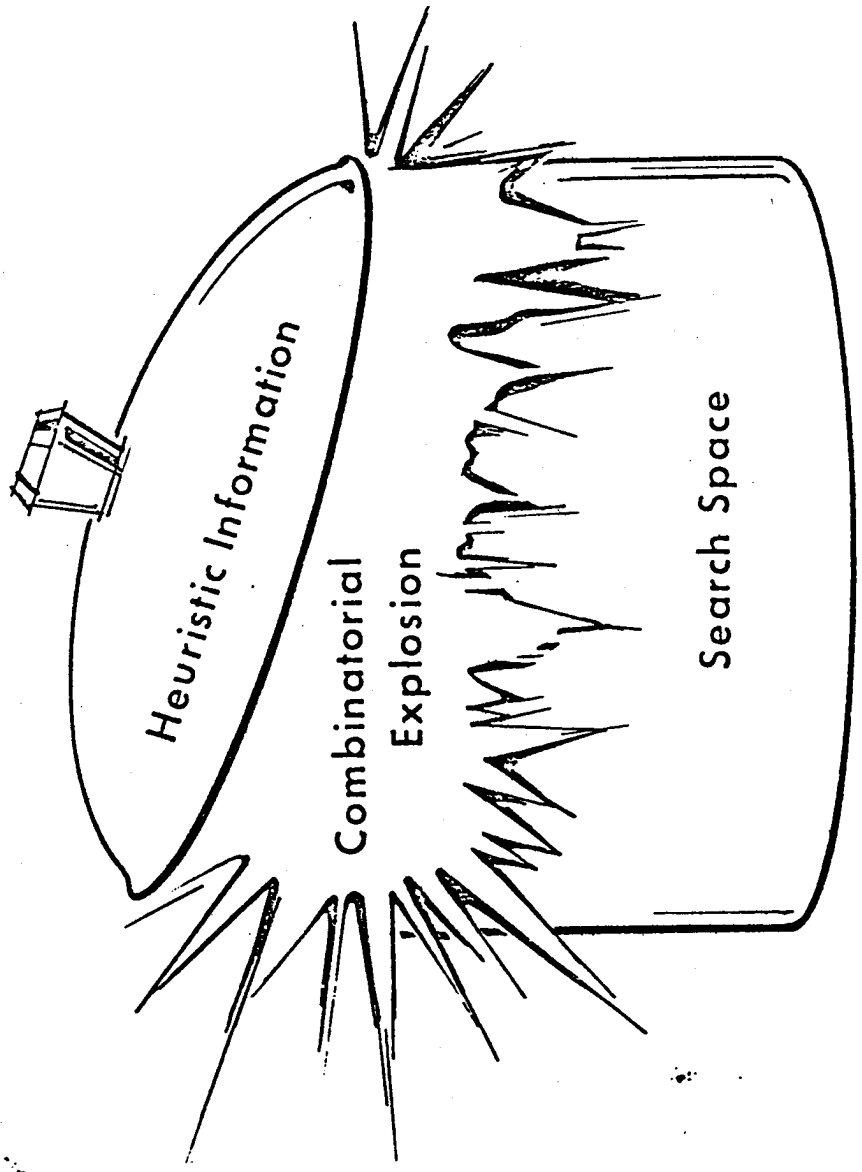
Search Feasibility



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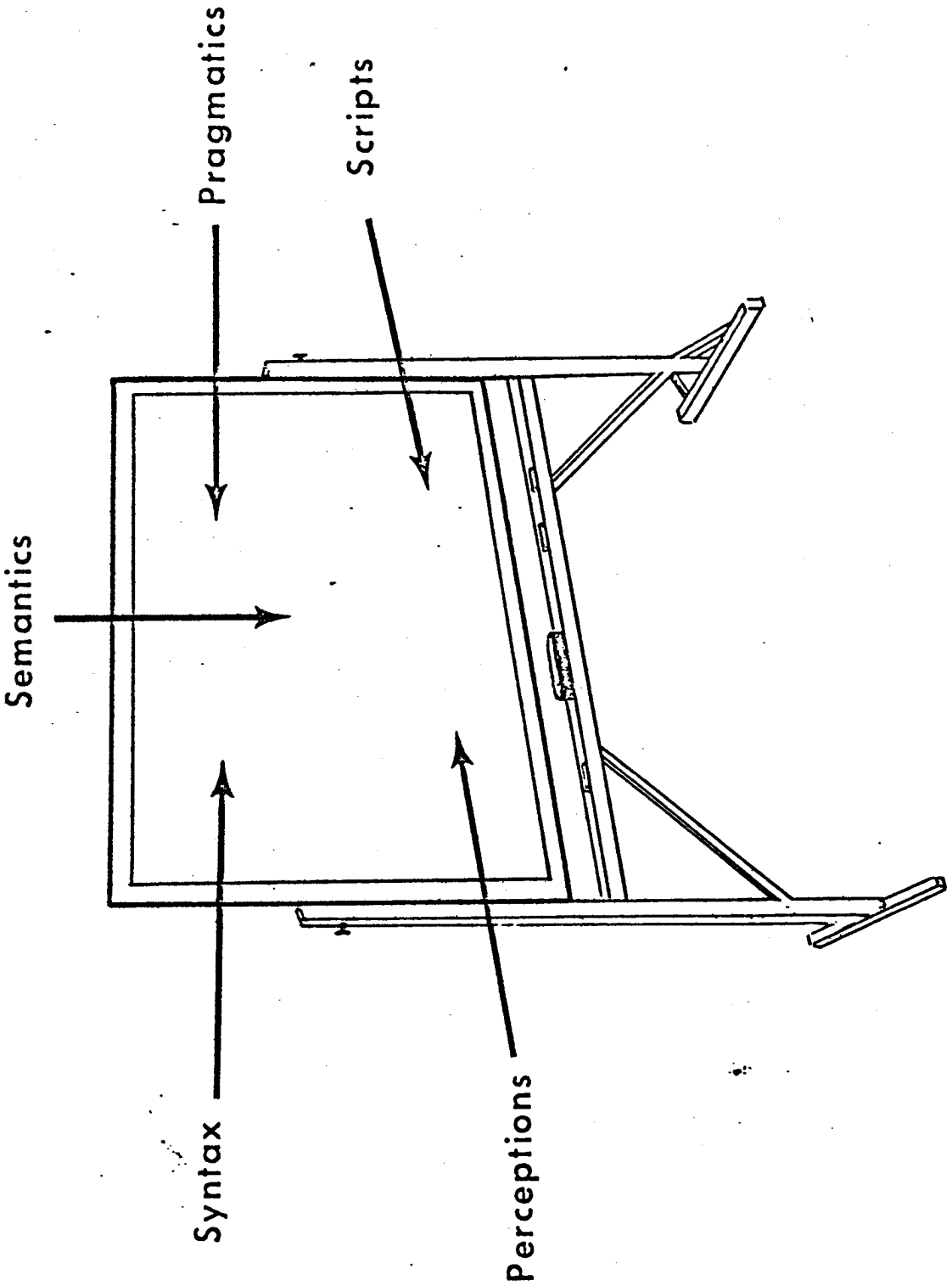
Multiple Knowledge Sources



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Knowledge Engineering Tools

LANGUAGES	SYSTEMS	KNOWLEDGE ACQUISITION	HARDWARE
• LISP	• EMYCIN	• KAS	• DEC 10/20/11/VAX
– INTERLISP	• ROSIE	• TEIRESIAS	• Xerox 1100
– MACLISP	• OPS-7		• Symbolics 3600
– FRANZLISP	• DADM		• LMI
– COMMONLISP			
.			
.			
.			
• PROLOG			

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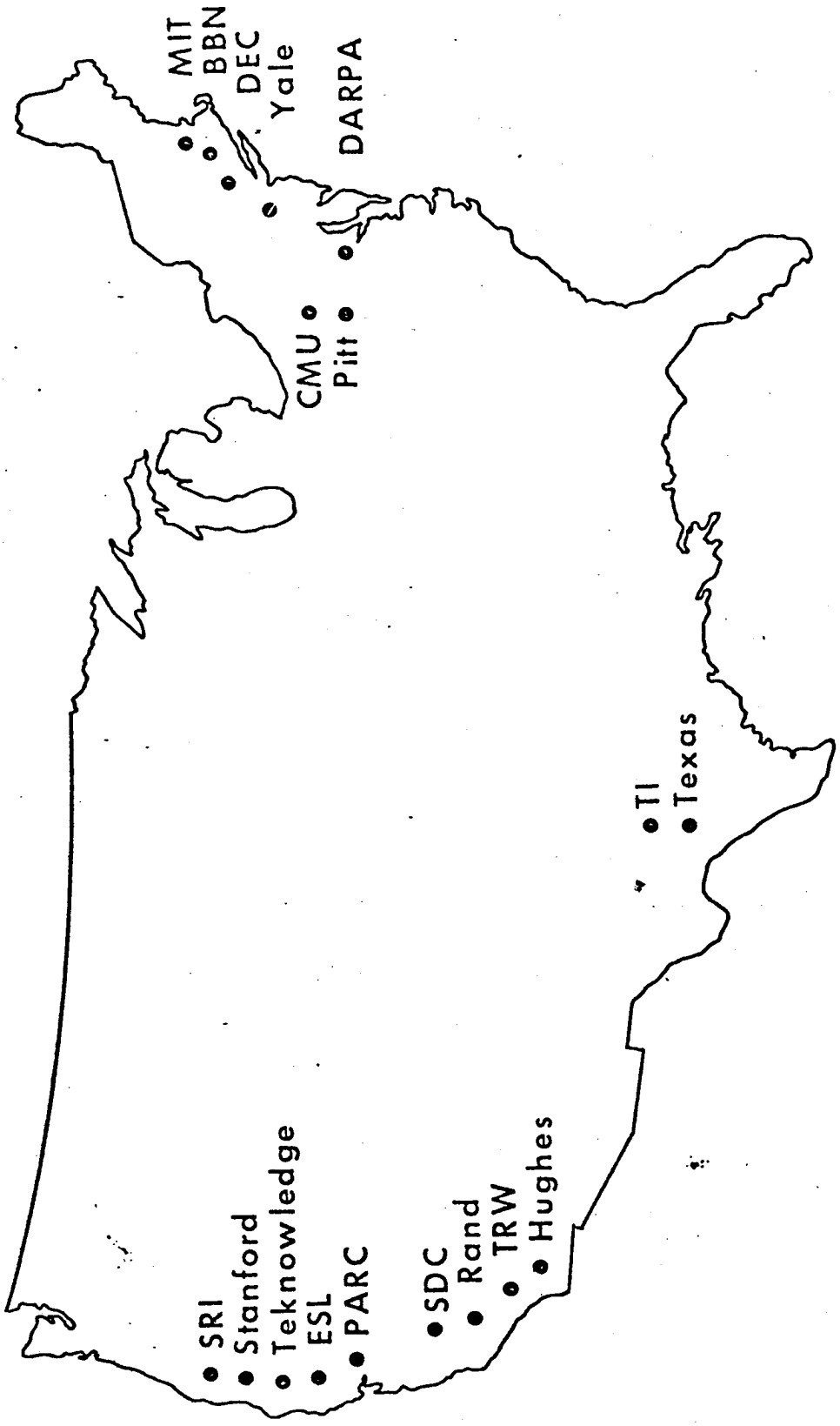
A/I R&D Activity



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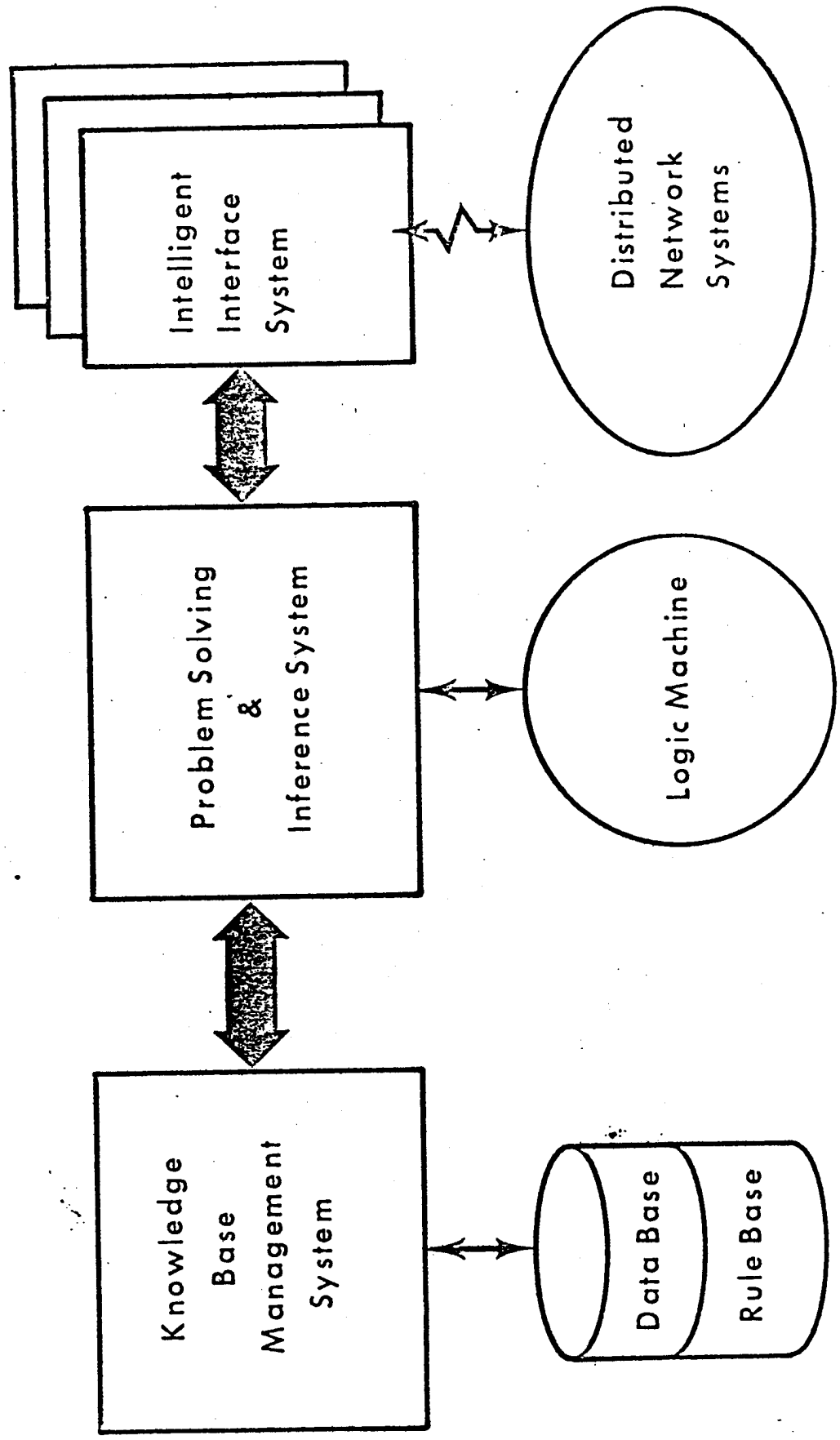
Fifth Generation Computers - Japan, Inc.



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"In The Knowledge Lies The Power"

-Teknowledge Corp.

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Inevitability

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